# ADOPTING A COMMERCIAL PROGRAMME FOR MEMORY REHABILITATION IN TRAUMATIC BRAIN INJURED PATIENTS?

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A research report submitted to the Faculty of Humanities, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of Master in Clinical Psychology.

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## DECLARATION

I declare that this research report is my own unaided work. It is submitted for the degree of Master in Clinical Psychology in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any other degree or examination in any other university.

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Hermias Cornelius Strauss

27th day of January 2006

## DEDICATION

To my lovely wife Lizelle,

My sons, Mias (Jr) and Dieter-Heinrich:

Without your devotion and support, I would have given up long ago.

You made me realize, especially during those very trying times,

That loved ones are what life is all about.

**And**

To my dad

This one is for you

Rest in peace

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## ABSTRACT

Memory is a collection of systems in the brain that work in conjunction with other systems and modalities to effect encoding, storage, retrieval, and learning of information. It also plays a part in the executive and other higher order functions (Banich, 1997). Patients who suffered a traumatic brain injury frequently have impaired memory functioning and a host of consequential problems as well. Rehabilitation of TBI patients is focused primarily on helping TBI patients to cope with and compensate for their disabilities (Hart, Whyte, Polansky, Millis, Hammond, Sherer, Bushnik, Hanks & Kreutzer, 2003) and one of the most important aspects of rehabilitation is memory (Quemada, Cespedes, Ezkerra, Ballesteros, Ibarra & Urruticoechea, 2003). In this study a commercially available memory enhancement program (Mega Memory® System) was used in an intervention with ten male TBI sufferers to evaluate its effectiveness in rehabilitation of memory. Subjects were assessed before and after the intervention on the Rivermead Behavioural Memory Tests and the Benton Visual Retention Test. Group results on Rivermead did not show any significant improvement of memory functioning, but the Number Correct scores on the Benton did. All subjects showed improvement on different aspects of memory functioning, especially in the domains of memory for everyday events, verbal, figurative, and spatial memory immediately following administration of the program. Overall the changes in memory functioning was not significant.



Key words: Memory, Rehabilitation, Working Memory, Baddeley, Traumatic Brain Injury, Male subjects, Wechsler Memory Scales – Revised, Benton Visual Retention Test, Rivermead Behavioural Memory Test.

# CONTENTS

# INTRODUCTION

Memory plays a part in the executive and other higher order functions of people (Banich, 1997) and patients who suffer a traumatic brain injury frequently have impaired memory functioning and other deficits which require rehabilitation. In the past, rehabilitation of TBI patients has focused primarily on helping TBI patients to cope with and compensate for their disabilities (Hart, et al, 2003).

Memory rehabilitation is an important aspect of rehabilitation (Quemada et al, 2003) and various products and methods exist commercially, which lay claim to improvement and enhancement of memory. One such commercially available product is the Mega Memory® System, which is marketed in South Africa by Home & Comfort, in Brackenfell, Cape Town South Africa.

In this study, the Mega Memory® System was adapted and administered to ten TBI sufferers to determine and evaluate its effectiveness as an memory enhancement intervention in rehabilitation of TBI patients.

After subject selection, they were assessed on either the Benton Visual Retention Test, or Rivermead Behavioural Memory Test using a pre- and post-test research design to elicit changes in memory and to investigate the effects of the Mega Memory® System on the memory performance.

Because the subjects differed in terms of injury localisation and effects, it was expected that each subject would experience the intervention differently and thus would have different outcomes in terms of the test results.

The test result data was analysed using nom-parametric statistical procedures and then interpreted to highlight changes in memory functioning and reach conclusions about the effects and usefulness of the Mega Memory® System.

# LITERATURE REVIEW

## Traumatic Brain Injury

Memory impairment is one of the most frequent neuropsychological sequelae of brain injury (Thöne, Zysset, & Yves von Cramon, 1999) and often the most disabling (Strubb & Black, 1977). It is a debilitating condition and the consequences of traumatic brain injuries are not always obvious which contributes to the problems of TBI suffers (Gentleman, 2001). Paradoxically, the most troublesome problems after TBI are often the least obvious to a casual observer, or even the patient and his/her family, who may all come to doubt that they have a physical basis.

Gentleman (2001) suggests that as the sufferer and family members try to make sense or come to terms with what has happened to their loved one they often are prone to misinterpret what they see. They often label it in terms of a psychiatric illness or character flaws such as laziness or stupidity. This could lead to misunderstandings and further damage the brain-injured person's already fragile self-esteem, relationships, employment, and claims for benefits or compensation.

The risk of this misunderstanding is especially high when physical recovery has been excellent and there are no visible clues to the extent of the problem. Gentleman (2001) maintains that although it is easy to see that someone walks with a limp or cannot speak, it is more difficult to observe difficulties with 'executive' tasks like planning a meal, or divided attention between competing stimuli such as group conversations. Gentleman (2001) further maintains that the physical and cognitive problems caused by brain damage are often worsened by low mood, irritability, and social disinhibition. This further disadvantages the individual within family, job, and social settings. Brooks (1991), who argues that psychosocial problems for both the TBI sufferer and the family tend to grow over time, corroborate this. Over half of all severely brain-injured individuals and their families exhibit such problems one year after the event, unless treatment is initiated.

When a multi-system trauma is sustained, it is likely to lead to troublesome physical complications that aggravate the effects of the TBI itself: Brain injury often causes diplopia, or restricts the visual field (usually a quadrantanopia or a hemianopia) which requires expert ophthalmologic assessments. Similarly, hearing loss and anosmia (reduction or abolishment of smell) often occurs after TBIs and could to be permanent with an associated reduction in taste (Gentleman, 2001).

However, TBI sufferers generally exhibit other problems as well: Many patients with significant TBI exhibit short-lived behavioural problems when they emerge from comas or other disordered states of consciousness (Gentleman, 2001). Low mood is the most common emotional problem after TBI and occurs even in quite mild cases. Several causes for this may exist simultaneously, e.g. altered neurotransmitter balance caused by the TBI, or a depressive reaction to the practical consequences of the injury. These behavioural problems often cause family members to become stressed and distressed, out of genuine embarrassment and fear of what the future may hold when they see the emerging patterns of behaviour. Behavioural symptoms are among the most damaging to a family that is trying to rebuild itself after one of its members has suffered a serious TBI (Levin, Gary, Eisenberg, Ruff, Barth, Kreutzer, High, Portman, Foulkes, & Jane, 1990).

TBI patients with physical and cognitive disabilities can place huge, financial demands as well as less tangible burdens on family members and government funded institutions. Hart et al. (2003) maintain that the resultant neurobehavioral problems of TBIs have been associated with vocational failure and other social problems. TBIs cause multiple impairments and of these, cognitive and behavioural deficits are more likely than physical limitations to preclude successful return to work or other forms of social productivity.

Most individuals report cognitive problems and deficits in attention and speed of information processing after suffering a TBI (Levin et al, 1990). Similarly, deficits in working memory are common (McDowell, Whyte & D'Esposito, 1997). This is supported by the research of Umile, Sandel, Alavi, Terry, & Plotkin (2002) who found that the most common cognitive problems after TBI were memory deficits, concentration and information processing problems, as well as word-finding difficulties. A significant proportion of people who have sustained a severe TBI will display impaired memory storage and retrieval problems on verbal learning tasks, up to one year following their injury (Hart et al, 2003). Impairment of memory impacts on the ability of TBI patients to maintain an emotional level or cognitive set, determine antecedents and consequences of behaviour, learn new information, and reason effectively (Makatura, Lam, Leahy, Castillo, & Kalpakjian, 1999). Thus the ability to plan, initiate, sequence, terminate, and monitor a wide variety of tasks may be compromised (Hart et al., 2003).

Gentleman (2001) support this and mentions that the biggest problem after a TBI, appears to be memory disorders which affect cognition and thus attention, memory functions, perception, information processing, problem solving ability, and executive functions. Since TBI affects primarily young adults, the societal burden and personal hardships that it creates, even in the form of many years of lost productivity, emphasises the importance of caring for survivors of TBI and stresses the importance of rehabilitation. Functionally, this can limit the ability to follow a conversation, plan activities, travel independently, initiate use of compensatory strategies, and complete the activities of daily living (Hart et al., 2003).

## Memory

Memory impairment due to traumatic brain injury may affect the whole being of the person as indicated by Erickson, & Scott (1977), who viewed memory as a higher order function expressing itself in performance that is inextricably bound up with the functioning of the total person and which forms part of the cognitive function of the human psyche. These memory functions include the acquisition and the retention of information, which constitutes learning.

Although several definitions of learning exist, it can be summarised as the acquisition of new information, mastering a new skill, developing a new habit and remembering personal experiences (Baddeley, 1997). Learning then, involves a consolidation process build on the hypothesis that information is stored and continuously reorganised, based on meaning. Learning presupposes memory, which has been divided into the constructs of long-term memory (LTM) and short-term memory (STM).

Long-term memory was described as a repository with seemingly limitless capacity, into which processed information from the short-term memory is deposited (Parente, Kolakowsky-Hayner, Krug & Wilk, 1992). During the early years of memory research, LTM has been further subdivided into memory for specific autobiographical events (episodic memory) and for context-independent knowledge (semantic memory) (Tulving & Donaldson, 1972). More recently, Squire (1992) distinguished between declarative (or explicit) and nondeclarative (or implicit) memory. Declarative memory refers to the ability to learn about, and remember, information, objects, and events. (Recalling of information that has previously been stored refers to the term remembering). Declarative memory is the type of memory that patients usually refer to when complaining of memory problems (Lezak, 1995). Non-Declarative memory refers to memory that relies on skill-based learning, and appears to be more robust than declarative memory rendering it less affected by brain injuries in general (Lezak, 1995).

Gilboa (2004), suggests that episodic memory (memory for autobiographical events) is quite a rare type of memory that serves as a bridge between working memory and long-term memory, and is measured in the order of minutes to hours. Baddeley, Wilson & Watts (1995) viewed semantic and episodic memory as the accumulation of ‘many episodes’ of events. They explain this analogy by viewing individual episodes like records (or CD’s) which are piled onto one another. From here, episodic memory represents the capacity to retrieve a specific episode from the pile and semantic memory the capacity to look at the pile form above whilst drawing out those features that are common to many of the constituent episodes.

However, during the 1950’s the processes for learning and retention were thought to be non-specifically localised as supported (at the time) by engrams taken during learning and retention activities by Lashey (Kolb & Whishaw, 1996). This notion was supported for years until new emphasis on memory functioning emerged with the now well-known case of H.M. who suffered a bilateral medial temporal lobe resection to reduce severe epileptic seizures (Kolb & Whishaw, 1996). As result, the resection produced severe anterograde amnesia and emphasised the effect that trauma has on memory function. The case of HM contributed to a shift in the emphasis of memory research; concentrating more on the processes of memory as compared to its localisation. This new emphasis resulted in theoretical development that aimed to better explain the processes involved in memory, learning, retention, and recall (Kolb & Whishaw, 1996). Several different theories of memory and its accompanying constituents were proposed. These ranged from early neuro-physiological theories to cognitive theories, including theories of the sensory store, short-term store (STS) and long-term store (LTS) as proposed by Atkinson & Shiffrin (1968), to the more recent theories of Baddeley (1992), which emphasise the replacement of the short-term memory store with a working memory system.

## Theories of memory

Atkinson & Shiffrin (1968) proposed a modal model of memory, which assumed that information is processed in parallel by a range of sensory buffer stores. These feed information into a limited capacity short-term store (STS), which in turn communicates with a long-term store (LTS). It proposed that the STS plays a crucial role in this model, since without it, no information can get into or out of the LTS. It also implied that the STS played a controlling role. They maintained that the longer information is kept in the STS (rehearsed) the greater the chances are that the information will be transferred to the LTS. They thus made a distinction between structural features of the memory system and control processes such as the rehearsal buffer (which is in essence an information loop) and which allows to keep input data for a longer period in the memory network (short term store), thus effecting better laid down traces of memory into the long term store.

This ‘modal’ model of a serial store for memory was the dominant theory of memory for many years until research elicited findings that were not supportive of the modal model (Shallice & Warrington, 1970, Craik & Watkins, 1973). Some of these findings contradicted the notion that the STS are the crucial determinant for learning, reasoning, and intellectual performance (Shallice & Warrington, 1970).

As research into memory progressed and new theories developed, memory was generally considered as relying on the interplay of a number of interacting components. Such as long term memory (LTM) essentially involved in encoding and retrieving information after lengthy delays, and short-term Memory (STM) which is involved in the on-line maintenance and active manipulation of information, as received by the senses (Thatcher & John, 1997).

Initially the processing of memory was thought to be at least a three-staged process where two succeeding stages, short-term memory storage and intermediate memory storage (Thatcher & John, 1997) led to a third long-term memory storage, as proposed by Wilson (1986). This model dominated the literature for quite some time and gave impetus to the theories of Baddeley (Broadbent, McGaugh, Kosslyn, Macintosh, Tulving & Weiskrantz, 1986) that led to the working memory model, which is more comprehensive and explanatory than the short-term memory model of Atkinson & Shiffrin (1968).

Baddeley (in Broadbent, McGaugh, Kosslyn, Mackintosch, Tulving & Weiskrantz, 1986), named the storage capacity of STM ‘Working Memory’ and proposed the existence of an executive system consisting of a central executive (a controlling attentional system) that supervises and coordinates a number of subsidiary slave systems. Baddeley’s description of working memory thus included three main components: the articulatory loop, the visuo-spatial sketchpad, and the central executive system, which are all applicable to this research.

The articulatory loop has two components: a passive phonological store that accumulates verbal material, and an active articulatory rehearsal process that preserves and processes verbal material within memory (Broadbent et al, 1986). The model proposes that all verbal material (information) remains in the phonological store for a few seconds. In order to keep the verbal material resident, it is cycled continuously through an active articulatory rehearsal process (often silent or sub-vocal) every 1.5 to 2 seconds. Without rehearsal, the information begins to decay. Baddeley (in Broadbent et al, 1986), argued that the phonological store was speech specific although this concept was disputed by Cowan (1996).

The visuo-spatial sketchpad also has two subcomponents: the visual component (also known as the visual short-term memory storage component) which stores information about an object's appearance, while the spatial component processes direction (Baddeley, 1974). Spatial functions include planning, monitoring changes in the perceptual field, maintaining orientation, and the perception of movement. The mechanics of processing in the visuo-spatial sketchpad are not yet as fully theoretically developed as that of the articulatory loop.

The central executive controller generally has a strategic function that integrates information both within the articulatory loop and visuo-spatial sketchpad and between them. It prioritises information processing, and controls attention and the allocation of rehearsal. The executive system thus takes up some portion of the available resources in working memory, because of it's functions of organising, controlling and allocating of processes and resources in and between the articulatory loop and in the visuo-spatial sketchpad (Baddeley, Vargha-Khadem & Mishkin, 2001). Information that was managed by the central executive and that fulfilled its purpose in the short-term storage domain, flows to long-term memory (or secondary memory) thus referring to the longer, more permanent storage of information.

The gathering of data through the senses, keeping them in STS and then laying them down in LT storage is the processes of learning, which means encoding, storage, and retrieval of information (Kolb & Whishaw, 1996). Storage refers to the integration of new information and its laying down into the schemas existing in long-term memory (Squire, 1992; Kolb & Whishaw, 1996). One of the methods of laying down information is mnemonics (forming images of words and imagining them to interact), which have long been known to enhance learning and memory (Baddeley, 1997).

Retrieval of information, refers to the ability to access and assess all previously laid down information, and is more efficient if the schemas are strongly associated, well organised and have many links to other bits of information (Eysenck & Keane, 1999). To this effect, Baddeley (1997) have found that priming (receiving a clue or cue) may be very effective, and make recall easier if structures within memory exist that represent familiar items.

However, retrieval of information sometimes can be difficult or even impossible. Several reasons for this exist commonly known as memory lapses, forgetting or poor memory. In this regard, Baddeley (1997) refers to prospective memory and retrospective memory lapses. The distinction between them is: *when* something needs to be remembered (prospective) and *what* need to be remembered (retrospective). Prospective memory typically has a very low information content, while retrospective memory tend to be concerned with the amount of information that need to be recalled. The mechanisms of long-term remembering (retrieval and recall) are not as well understood as those of working (short-term) memory, Research in the field of autobiographical memory loss (such as retrograde amnesia showed that in some instances, an improvement in memory functioning, can be expected, although the severity of the initial memory loss was severe (Baddeley, 1997).

Memory and related cognitive processes are supported and carried out in the brain and thus make these processes susceptible to brain trauma, which invariably affects cognition. The mechanical damage to nerve cells and their connections, caused by traumas, not only affect physical function but also affect a wide range of neuropsychological functions (Conzen et al., 1992; McAllister, 1992). Ellenberg, Levin & Saydjari (1996) maintains that one the best indices of the severity of a diffuse TBI is the duration of post-traumatic amnesia (PTA) the length of time from injury before the return of continuous memory function. PTA can only be estimated retrospectively, and accordingly Gentleman (2001) maintains that it is notoriously susceptible to underestimation because many TBI patient report islands of memory before they emerge from PTA.

He further maintains that the brain damage that causes this is every bit as organically based as the damage that causes motor impairment or the loss of expressive speech and that it can often be visualized by cross-sectional imaging, and by increasingly sophisticated functional imaging (Gentleman, 2001). Memory impairment after TBI is characterised by a long-term memory deficit, that is, difficulties in recalling or recognising information after an interval (Goldstein & Levin, 1995).

## Assessment of memory and the Mega Memory ® System

Because memory is so fundamental to overall functioning, its measurement via neuropsychological testing in rehabilitation settings is crucial. Clinical memory testing is generally comprised of standardised tests focusing on different aspects of memory (Lezak, 1995). Tasks involved in traditional clinical assessment include retelling of a story immediately after presentation and after a delay, learning of figures, colour combinations, learning of word pairs, reproducing simple geometric figures immediately and after delay, and learning word lists.

One widely used instrument that typifies this type of assessment is the Wechsler Memory Scale Revised (WMS-R) (Wechsler, 1987). Tasks in this test include remembering names, faces, routes, and appointments, which utilises the two major components of working memory as per Baddeley's model, namely the visuo-spatial sketchpad and the articulatory loop. Thus, the WMS-R was the instrument chosen in this study to determine the general memory abilities of the subjects before the intervention.

The Mega Memory ® System utilises mnemonics, which implies visual generation of pictures in 'the minds eye', and which require a continuous sequential linking of these images (objects) in order to form a type of story line. However, the WMS-R as instrument tend to focus on memory functioning (how memory works), and although this information is useful in determining the extend of memory deficits that may exist, it does not tell much about the practical applicability of memory (Wilson, B. 1993).

Depending on the purpose of the assessment, a variety of assessment instruments is available for use by clinicians. According to Lezak (1995), hardly any neuropsychological test will ever meet all validity criteria, and the validity will vary with the use to which the test is put. Some instruments may serve different purposes or may be specifically applicable for specialised purposes (Lezak, 1995). In order to obtain a more relevant picture about the practical effects that the Mega Memory ® System will exert on everyday memory functioning, other instruments, encompassing both the advantages of standardisation and ecological relevance, were included in the research.

The Benton Visual Retention Test (BVRT) (Sivan, 1992) is widely used as a visual recall test for diagnostic purposes in neuropsychology, impacting primarily on the visual-spatial component of working memory thus rendering it applicable to this research. It tests immediate and delayed recall, is sensitive to unilateral spatial neglect and provides a measure of immediate span of recall (Lezak, 1995).

The Rivermead Behavioural Memory Test (RBMT) (Wilson, Cockburn & Baddeley, 1985), was developed to provide measures that could be directly related to the practical effects of impaired memory and for monitoring change with treatment of memory disorders. The RBMT is essentially an atheoretical test meaning that it focuses on practical applications of memory rather than on conceptualisation of the constructs of memory. It measures memory performance on tasks typical in everyday activity, draws on both the articulatory loop and visuo-spatial components of working memory, and thus was included as a monitoring instrument in this research. Its usefulness in this regard is supported long-term research done by Ownsworth & McFarland (1999) and others researchers (Wills, Clare, Shiel & Wilson, 2000).

## Rehabilitation

Generally, rehabilitation is based on the knowledge and information gained from theories and subsequent research into memory, and as such, also varies and needs to be adjusted to complement current understanding of memory problems. However, ideally, rehabilitation of TBI patients must be based on the principles of adult education that imply a process in which the traumatic brain injured patient must engage and, ideally, help steer. Patients often cannot do this at first, and rehabilitation then has to be planned by a multi-professional team, working with the affected person and caregivers (Gentleman, 2001).

Depending on the exact problem, a wide range of treatment approaches (not mutually exclusive) have been tried in structured rehabilitation programmes: For instance: (1) internal strategies teach the brain-injured person to use mental imagery, to organise information in sequences, or to use acronyms and rhymes (Gentleman, 2001): and (2) practical approaches and interventions are devised to reduce the handicapping effect of memory problems, e.g., a personal organiser with alarm systems, colour codes around the house, or routine use of lists and diaries. These techniques do not affect the memory impairment of the sufferer but reduce its handicapping effects, and consequently have positive benefits for the brain-injured person and his/her family (Gentleman, 2001).

Thus, appropriate rehabilitation of TBI patients is, without doubt, beneficial to the patient and caregivers alike since a TBI can alter role relationships, creates marital disruption, and place great strain on family systems. It is generally accepted that employment and return to work after TBI is a good indicator of successful rehabilitation (Jones & Evans, 1990). They found that both caregivers and financial providers of TBI patients consider an improvement in employment status, control of problem behaviours and improved communication skills as the highest priorities for rehabilitation outcomes.

Employment levels may certainly be an indicator of general functioning, but the level and amount of assistance required in daily activities also forms a critical measure of success after TBIs since it may be costly both in terms of financial assistance and in terms of stress on the TBI sufferers and caregivers. However, the severity of brain injuries directly influences time of recovery, posttraumatic levels of functioning and sequelae and thus has direct financial consequences. In support of this notion, Sander, Kreutzer, Rosenthal, Delmonico & Young, (1996), and Fabiano & Crewe (1995) found that sixty-five to ninety percent of those who had suffered mild traumatic brain injury were able to return to competitive employment, compared to almost seventy percent unemployment for sufferers of severe traumatic brain injuries.

Although an increase in the advancement of TBI patient rehabilitation has taken place over the past years, healthcare funding and other living costs complicate the process of rehabilitation and thus also the expected outcomes (such as return to work) and duration of rehabilitation (Leahy & Lam, 1998). Mild TBI patients require less rehabilitation than severe TBI patients do, but there is a financial incentive to subject persons with severe traumatic brain injuries to a rehabilitation programme. Aronow (1987) found that participation in a rehabilitation programme delivers better cost-outcomes than non-participation. This supports earlier research by Prigitano et al (1984) who found modest levels of improvement in employment and neuropsychological functioning with subjects who completed a comprehensive rehabilitation programme after suffering a severe traumatic brain injury, as compared to a control group.

As the severity of the TBI will affect the rehabilitation process in terms of duration (thus costs) it necessitates the need for careful planning of interventions that will negate costs and affect positively on the quality of life of TBI patients. This means that the patient, their significant others, and financial provider(s) must together direct efforts to obtain a feasible course of rehabilitation while maximising the value of such interventions (Leahy & Lam, 1998). As an inexpensive programme, the Mega Memory ® System thus qualifies in this respect.

An important complicating factor in rehabilitation is found in the nature of brain injuries in that these involve damage to the very mechanisms by which information is processed, stored, and retrieved. Thus, understanding the type of impairments and natural recovery thereof, as displayed by TBI patients, assists and enables the development of more precise rehabilitation plans (Kershel, Marsh, Havill, & Sleigh, 2000). Furthermore, when rehabilitation of TBI sufferers is considered, it has to be kept in mind that their unique personalities and library of experiences interacts with the evolving processes of biological damage and recovery, meaning that apparently similar lesions in different individuals may not present with exactly the same clinical consequences.

Deficits in attention, problem solving, perception, and other cognitive functions can be alleviated by different techniques and interventions: Based on the working memory model of Baddeley, and in particular on the visuo-spatial sketchpad process, Vaidya & Gabrieli (2000) found that pictures could have a mnemonic advantage in rehabilitation exercises that use a combination of pictures and words to stimulate recall. This is a feature employed by the Mega Memory ® System in delivering its content.

The advantage of naming pictures on recall raises the possibility that different conceptual information about pictures, such as size, form, shape, colour etc., may be brought to bear which assist recall of information (Vaidya & Gabrieli 2000). They further maintain that visual distinctiveness of pictures affects recall but not priming (assisting recall by previous exposure to an object), suggesting that additional conceptual processes are relevant for explicit memory in general or cued recall in particular. Mental imagery again, can assists with learning, as shown by Malouin, Belleville, Richards, Desrosiers & Doyon (2004), who utilised mental imagery (visualisations) in rehabilitation efforts with stroke patients.

## Memory and Mega Memory®

Given the advantages of memory rehabilitation for TBI sufferers, this study adapted and applied the commercially available Mega Memory® system (Green, 2002), as presented by Kevin Tredaux as a possible cost effective memory enhancement instrument. This programme was chosen because of its general availability in the market at a reasonable cost, and because of the interesting combination of visualisations and other mnemonics that it employs which requires short-term memory utilisation and enhances long-term storage of information (secondary memory). It draws on the working memory constituents of the articulatory loop, visuo-spatial sketchpad and executive controller functions to combine auditory, semantic, visual, and episodic memory to attain learning. More specifically it utilises both the phonological loop and visuo-spatial sketchpad, to assimilate and produce information in the two separate stores and it uses the executive controller to "manage" the processes involved in laying down the 'concepts that has been learned' into LTM.

The distributors of Mega Memory® System (Green, 2002), claim that it "provides easy-to-learn memory techniques that rapidly become part of your new way of thinking". Thus determining the effectiveness of the Mega Memory® System as an intervention in rehabilitation aimed to improve general memory functioning of TBI patients was the main objective of this research.

### Hypothesis

By administering the Mega Memory ® System, it is expected that an improvement in memory function of TBI subjects will occur. This improvement will be determined by the measuring the differences between the pre-intervention and post-intervention scores that the subjects obtain on either the Benton or the Rivermead tests.

## METHOD

### Research Design

The objective of this research was to determine the effectiveness of the Mega Memory® System on memory functioning of TBI patients. This can only be done if changes in memory functioning is measured.

Determining the base level and specific impairments of memory functioning of subjects would require a valid and appropriate assessment instrument. Similarly, and depending on the emphasis of the research, instruments that measure changes in general or specific areas of memory functioning, would be used to obtain data reflecting the "before" and "after" memory functioning of subjects. For this purpose the Wechsler Memory Scales – Revised, the Benton Visual Retention Test, and the Rivermead Behavioural Memory Test were used. Statistical analysis would determine acceptance or rejection of the hypothesis and allow conclusions about the effectiveness of the Mega Memory® System to be drawn.

## Subjects

Brain injuries of any nature, whether closed head injuries, open wound injuries, or even cerebro-vascular incidents are considered traumatic by nature and were included as accepted qualifying criteria for subject selection. Subjects that suffered a TBI, or who fall within the ambit of severe traumatic brain injuries, and who were willing to participate in the study were contacted through Headway Gauteng in Johannesburg. Headway Gauteng is a non-profitable organisation, which specialises in rehabilitation of traumatic brain injured patients. As they accommodate TBI sufferers from across Gauteng province, they have sufficient numbers of brain-injured people in various stages of recovery after injury, and who regularly attend the rehabilitation programs on offer.

Ten male traumatic brain injured patients were selected to participate in the study. General inclusion criteria for the research required subjects to have a good working knowledge of English (the Mega Memory® System is presented in English), and were expected to be able to engage in a relatively reliable two-way communication, with or without assistance of some sort (e.g. electronic voice machines etc.). Subjects had to be between the ages of 20 – 45 in order to eliminate possible variables such as the influence of ageing on memory and learning (Negash et al, 2003). They had to be male to (1) limit possible variables relating to gender issues and (2) potentially create a larger pool of potential subjects, since the prevalence of TBIs are higher amongst males (Kershel et al, 2001). A rating of seven or eight on the Glasgow Coma Scale (Ghajar, 2000) on admission to hospital immediately following the injury was required. The time elapsed since injury should be between five and seven years to allow for normal healing processes and adjustments to be established. Another requirement for participation in the research was the absence of severe psychiatric disturbances and the ability to participate to some degree in and handle social settings. Due to time constraints, the subjects were randomly assigned to two for administration of either the Benton or the Rivermead tests, so not all subjects did both tests.

## MATERIALS

Two kinds of test validity holds special interest for neuropsychologists, they are face validity and predictive validity (Sivan, 1992), both of which are largely applicable to the tests as employed in this study.

### Wechsler Memory Scales – Revised (WMS-R)

The Wechsler Memory Scales – Revised (WMS-R) (Wechsler, 1987) is designed to measure five global dimensions of memory (Attention and Concentration, General Memory, Visual Memory, Verbal Memory, and Delayed Memory). The WMS-R was introduced in 1987 as an extended device for diagnosis and screening of brain-injured patients. It has been used extensively with patients who have sustained brain damage or suffered from a brain disease (Hopkins, Waldram & Kesner, 2004; Makatura, Lam, Leahy, Castillo & Kalpakjian, 1999; Mangels, Craik, Levine, Schwartz & Stuss, 2004; Rath, Langenbahn, Simon, Sherr, Fletcher, & Diller, 2004; Temple & Richardson, 2003).

Scoring of WMS-R sub-tests which deliver raw scores are done according to guidelines in the manual (Wechsler, 1987) and the equivalent percentile scores are obtained from the relevant tables in the manual. These scores as based on the Index scores which were obtained from the raw scores of the standardisation sample of a normal population (n=50 per age group). Age groups as indicated in the manual are 16 – 17; 18 – 19; 20 – 24; 25 – 34; 35 – 44; 45 – 54; 55 – 64; 65 – 74.

The mean and standard deviation for raw scores per age group were determined to be 100 and 15 respectively, which translates into percentile equivalents ranging from 16th percentile (index score 85, SD=1) to 84th percentile (index score of 115, SD=1). Mean index score of 100 is thus equivalent to a percentile score of 50. According to the manual, a comparative study with close head injured subjects; lower scores were obtained on all indexes when compared to non-injured subjects ($p<0.0001$). The only significant difference in scores were on delayed recall ($p<0.02$) (Wechsler, 1987).

According to Lezak (1995), test performances that are communicated in terms of ability levels expressed in percentile ranges, have generally accepted and relatively clear meanings. This is particularly applicable to the WMS-R test scores. Ability levels for the WMS-R are thus classified as Very superior (98th percentile and above), superior (91st percentile to 97th), high average (75th to 90th), average (25th to 75th), low average (9th to 24th), borderline (2nd to 8th) and retarded (below 2nd) (Lezak, 1995).

Because of the storyline nature of the Mega Memory ® System, the following subscales of the WMS-R were used: (1) Logical Memory I & II subscales (which give an indication of the extent to which an over load of data may compromise functioning), (2) the Visual Reproduction I & II subscales (which give indication of visual memory abilities) and the (3) Digits Backward and Forward (DB and DF) subscales (which gives an indication of attentional abilities) were used.

Logical Memory I is used to examine the subject’s ability to recall information from two verbally presented stories. For both LM I & II a maximum score of 25 is obtainable. Logical Memory II is used to determine the delayed free recall ability of a subject, based on the same stories but after a delay of 30 minutes, and is scored in the same manner as the Logical Memory I subtest. It is expected that subjects who suffers from an impaired articulatory loop functioning as per Baddeley’s model (Baddeley et al, 1997), would obtain scores that fall in the below average and lower ranges for LM I. If consolidation of information (encoding, storage and retrieval) was impaired, it is expected to be indicated by similarly ranged scores for the LM II subtest.

Visual Reproduction Subscale (VR-R) I and II is used to assess visual memory an is administered by presenting four cards with different geometric designs for approximately five seconds to the subject. For administration of VR-R I, the designs are copied immediately after presentation by the subject and scored according to the guidelines from the manual. The scores for VR-R II are obtained by requesting the subject to copy the designs after a 30-minute delay. Deficits in visual-spatial sketchpad functioning is reflected by below average range scores for VR-

R I and similarly, consolidation of visual information deficiencies by below average range VR-R II scores.

Digits Forward (DF) and Digits Backward (DB) tests are used to determine the attention and concentration span of subjects. DB is believed to share many of the cognitive components of DF and to have the additional component of manipulation of items in working memory. Therefore, DB is believed to more heavily involve the central executive component of Baddeley's model (Gerton, 2004). It is expected that the scores for subjects exhibiting attentional problems would be reflected by below average range scores on these sub-tests.

## Rivermead Behavioural Memory Test

The Rivermead Behavioural Memory Test (RBMT) (Wilson, Cockburn & Baddeley, 1985) was developed to provide measures that could be directly related to the practical effects of impaired memory and for monitoring the effects of impaired memory as well as for monitoring changes due to treatment of memory disorders. Memory problems of moderately to severely injured head trauma patients are identified by this test. It is essentially an atheoretical test in which the emphasis is more on the practical application of test results than on principles of memory functioning (e.g. as can be found in the WMS-R) (Makatura et al, 1999). The RBMT was shaped and developed as a result of clinical experience with patients suffering from memory impairment and does have practical value especially for patients with memory disorders too severe to be fully independent (Lezak, 1995). Areas of everyday memory impairment are identified by the RBMT, which can assist caregivers and professionals to develop support strategies and rehabilitation interventions.

In contrast to many standardised tests, which rely on experimental measures, the RBMT consists of twelve subtests that are designed as analogues of everyday tasks reflecting the kinds of situations in which brain injured patients typically has trouble on a day-to-day basis. The tasks include remembering a person's first and last name, remembering a hidden belonging, remembering an appointment, picture recognition, remembering the gist of a short passage, face recognition, remembering a new route, delivering a message, answering orientation questions, and remembering the date. Remembering a short passage and remembering a route around the room have immediate and delayed–recall components.

Memory for common objects and for faces is assessed using a recognition paradigm in which subjects must identify the original items among distracters. Prospective memory is assessed on three measures: remembering at the end of the session to ask for a personal possession that was put away at the beginning of the session; remembering when an alarm rings to ask a specific question given when the alarm was set twenty minutes earlier; and remembering to take a message on the route around the room and deliver it at specific point along the route. Orientation items assess knowledge of time, place, and person. Four parallel versions of the RMBT exist which would allow elimination of the practice effects due to repeated testing.

As a screening test the RMBT was devised with two methods of standardising scores across subtests that allows for derivation of either a screening score, with subtests raw scores categorised on a scale of 0-1 (maximum score 12 points), or a standardised profile score, with subtests raw scores categorised on a scale of 0-2 (maximum score 24 points). According to the RBMT manual (Wilson, Cockburn & Baddeley, 1985), the cut-off points for level of memory functioning on the screening score, are as follows: Normal (10,11,12), poor memory (7,8,9), moderately impaired (3,4,5,6) and severely impaired (0,1,2). This classification of impairments was developed by the creators of the test, based on scores obtained from their sample of brain damaged patients (n=176) when compared to control subjects (n=118).

The screening score indicates whether a patient has memory problems sufficiently severe to interfere with every-day functioning. The more fine-grained standardised profile score provide a more sensitive analysis of performance and gives an indication of the degree of severity, and an examination of the pattern of performance across subtests identifies particular areas of difficulty (Spreen & Strauss, 1998). The screening scores will be calculated for the current research. It is expected that low screening scores on remembering a person's first and last name, remembering a hidden belonging, remembering an appointment and remembering the gist of a short passage would indicate deficiencies in working memory, and in particular within the articulatory loop component , since these tasks involve rehearsal of language based information.

Low scores on delivering a message, and remembering a new route is expected to be also indicative of articulatory loop deficiency, but also delayed recall and consolidation of information deficiencies. Low scores on answering orientation questions, picture recognition, and face recognition will be indicative of visuo-spatial sketchpad, deficiencies. Integrating both verbal and spatial information into consolidated meaningful information either during learning or recall, depends on the co-ordinated function of the articulatory loop and visuo spatial components of working memory.

Compromised delayed recall ability will thus be indicated by low scores on all items that require delayed recall such as the remembering of faces etc. However, Wilson, Cockburn & Baddeley (1985) found only isolated instances during their research and development of the RBMT where the test would clearly distinguish between visual and auditory memory deficits and thus they maintain that their subjects rather had generalised memory deficits that specific deficits.

## Benton Visual Retention Test

The Benton Visual Retention Test (Sivan, 1992) is a widely used test boasting several virtues including sensitivity to visual inattention problems and spatial organisational problems. The drawing administration of the Benton has three alternate forms (C, D, and E) that are roughly of equivalent difficulty. Each form is composed of ten designs; the first two designs consist of one major geometric figure and the other eight designs consisting of two major figures and a smaller peripheral figure. Four different administration formats exist, (administration A through D) which each differ in terms of time of exposure of the figures to the subjects. For this research, the most widely used administration method (A) was chosen:

Under administration A, the standard procedure, each design is displayed for ten seconds and then withdrawn. Immediately after this, the subject is required to reproduce the design form memory at his or her own pace on a blank piece of paper. The time required for administration is about five to ten minutes. In this test, the number of correct responses and the errors are scored. The errors that are recognised include omissions, distortions, perseverations, rotations, misplacements, and errors in size.

Normative standards for administration A are listed in the manual and are based on the data from three different studies (n>1300) (Sivan, 1992). The norms for number correct scores for adults as well as those for number error scores presuppose an estimated pre-morbid IQ score of subjects, and is then further divided into age groups.

The estimated premorbid IQ ranges are 110 and above, 95 – 109, 80 – 94, 70 – 79, 60 – 69, 59 and below. The age groups are 15 – 49, 50 – 59, and 60 – 69. According to the manual the Benton does not significantly distinguish between patients with and patients without brain disease, but is useful, especially in the case of the number error score, to monitor changes in performance over time (Sivan, 1992).

The BVRT is sensitive to both right and left brain damage. Its sensitivity is shown by the fact that head trauma patients tend to make significantly more errors than control subjects (Levin et al, 1990). Besides its sensitivity to visual inattention problems, it provides measures of immediate span of recall and spatial organisation. Lower than expected scores on the number correct scores is indicative of visuo-spatial sketchpad deficiency: visual memory and of visual inattentiveness. Lower than expected number error scores will be indicative directional and of spatial component deficiency of the visuo spatial sketchpad.

### Mega Memory® System

The Mega Memory® System consists of nine audiocassettes. One is dedicated to an introduction and welcoming message and the remaining eight cassettes contain the programme, with the exception of the last side of the last cassette, dedicated to a relaxation technique in the form of a pseudo-hypnosis audio presentation. In addition to the cassettes, a workbook with the same exercises as those on the cassettes is provided as a support to recap the essentials of the audio presentation. Exercises consist, of explanations and verbal instructions to the listener about the techniques of visualising certain images, and forming connections between those and other words or figures. These exercises become progressively more complex and build on the previous exercise, which necessitates the need to attend all sessions.

During the first lesson, the listener is familiarised with the intended content of the programme. It informs the listener that it will be working on both short-term memory and long-term memory, and then immediately moves on to illustrate the fact that items in short-term memory can rapidly be stored in and recalled from long-term memory. To illustrate this point, the listener is taught to remember a list of 20 objects, e.g. tree, light switch, stool, car, glove, gun, dice, skate, cat, bowling ball, goal posts, eggs, witch, ring, pay check, candy, magazine, voting booth, golf club, and cigarettes, in sequence. This is done by tasking the listener to visualise the object, when mentioned and then to associate a feature of the object with the number in the sequence. E.g., the object of number 5 is the glove. Its association would be the fact that a glove has five fingers.

After this first lesson in memory storage and retrieval, the Mega Memory® System then progresses to explain that although this method of memorising makes use of associations, formed between the items and its numerical sequence, it becomes a basic and unconscious process which will support the other methods that it will employ in memory enhancement. The other sessions start by teaching listeners about two basic reference systems that will form the basis for all other learning and memory enhancement that will take place:

The first reference system uses specific body parts as a departure point and the second uses four rooms in a home. For the body part reference-system to be committed to memory, the listener is initially requested to either touch or visualise the body parts and then repeatedly (seven times) requested to visualise the body parts in sequence. The room reference system requires the listener to mentally select four rooms in a house that is familiar to them and then to visualise five substantially large objects in each room. The listener is then requested to visualise walking through these rooms and vividly see the selected objects in their minds eye. This process is repeated several times, but gets progressively faster, until eventually the listener is requested to 'see' (recall) these objects as clusters of objects the moment the request to visualise them is made.

After these reference systems are committed to memory the programme then progresses to build on different visualisations that are linked to the body or house reference system. During these sessions, the listener is requested to start forming not only visualisations of objects, but to put different objects together in a story-line progression. Listeners are further requested to create story lines that involve movement of the objects in a sequential interaction with one another, and to make the actions as absurd as possible.  These methods of visualisations then can be used to commit to memory and recall lists of items or objects, routines, routes, events and to aid in learning.

The processes described above involve the working memory and its constituents: the passive phonological store that accumulate the verbal material (object words) and the active articulatory rehearsal process that preserves and processes the words by means of its phonological loop. The visual-spatial sketchpad is also actively involved in that the visual short-term memory storage component stores information about the object's appearance and the spatial component processes direction. Both immediate recall and delayed recall of items are required and as the list of objects increases, the demands on the central executive as attention controller and co-ordinator of the working memory sub-systems increase.

Changes in memory functioning of subjects that participated in the Mega Memory® System thus can be assessed with the Benton (sensitivity to visual inattention problems and spatial organisational problems) and the Rivermead for monitoring changes of everyday memory tasks, after treatment.

## PROCEDURE

The management of Headway were approached to obtain permission in order to conduct the study on their premises. The concept of the study, as well as the logistics for carrying it out was discussed and permission was obtained to approach their clients for participation as subjects in the study. After permission was obtained, arrangements were made for the research to be carried out:

Normal occupational therapy schedules were obtained and individual assessment times as well as sessions for administration of the Mega Memory® System were planned in conjunction with the occupational therapist. The subjects attend occupational therapy sessions twice a week, and thus the schedule made provision for assessments on the WMS-R (one day), the "before" assessment on either the Benton or Rivermead (one day), administration of the Mega Memory® System (16 days) and the "after" assessments on the Benton and Rivermead (one day).

Potential subjects and their caregivers were informed during a specially arranged session about the rationale of the research, the expected participation, and commitment of selected subjects, the duration, and the methods that would be used. Consent forms (see appendix A) were given to 14 potential subjects and collected from those who volunteered to participate in the study. The consent forms also contained sections where, by means of signature, permission was obtained to access private and confidential files and records. Biographical and other information pertaining to the individual potential subjects were gathered from their personal files at Headway Gauteng and from caregivers. Final selection of the ten male subject candidates was done based on the general selection criteria.

Once the subjects for inclusion in the study were identified, they were informed of the assessment and session schedules, and were again reminded of the importance of attending all sessions. Subjects were assigned an alphabetical number (A through J) in order to assure privacy of personal information, and to reflect the recorded data. Subjects were then randomly assigned to one of two groups for the purposes of assessment on the BVRT and RMBT.

As per the agreed schedule and during occupational intervention sessions, all subjects irrespective of the group they were assigned to were withdrawn individually to complete the Wechsler Memory Scales-Revised subtests. Once all subjects were assessed on the WMS-R and the data was gathered, subjects again were withdrawn individually to be assessed on form C of the Benton Visual Memory Test or on form C of the Rivermead Behavioural Memory Test in order to obtain the "before" data.

Once these assessments were completed and the data gathered, the administration of the Mega Memory® System took place. Since administration of the Mega Memory® System requires audio playback devices to deliver the material, each subject was supplied with a Walkman (a portable tape recorder / playback instrument with headphones). Prior to each session, administration, cassettes containing the particular session for the day, were inserted in the Walkmans, and cued to the starting point for the session. In accordance with the adaptations made to the Mega Memory® System, subjects were requested before each session, to ignore all references to the workbook on audio.

Once set up, subjects were invited to ask for assistance at any time during the sessions, should the need arise. All subjects were then requested to start their playback simultaneously. If subjects had motor impairments that prevented easy manipulation of the playback or stop buttons on the Walkman, assistance was provided.

After completion of the 18 sessions, subjects were again assessed on either form D of the Rivermead or on form E of the Benton, to collect the post-intervention data. All the different data sets were then transferred to computer for statistical analysis. As the normative standards of the Benton requires an estimated pre-morbid IQ score, and not enough information was available to form an indirect measure of estimation of IQ, it was decided to use the generally accepted average range of 90 to 110 IQ points (Lezak, 1995) as the pre-morbid IQ level of the 5 subjects for the Benton tests. The Benton range of 95–109 thus falls within this IQ range, and as such would be used for comparison of scores.

## RESULTS AND DISCUSSION

In this study, the performance of two groups of five subjects was measured before and after administration of the Mega memory programme to determine if the programme affected memory performance of the subjects on either the Rivermead or the Benton tests. The sample size necessitates the use of non-parametric data analysis. The preferred method (or tool) for use to analyse the data of this study, is the *Wilcoxon two sample test (*Zimmerman & Zumbo, 1990). Blair & Higgins (1980) have shown that the Wilcoxon test frequently is efficient even when sample sizes are small, as is the case in this research. The Wilcoxon was used to determine if there was a significant difference between the performance of the group of subjects before and after participation in the Mega Memory® programme. Benton and Rivermead test result scores of before and after administration were compared to determine any significance between them.

Since the sample size was small, and the individual subject cases so diverse in nature, Student *t* tests were conducted on the individual scores of the subjects to investigate if any significant change between the 'before' and 'after' tests results was achieved. The data collected are presented below by first giving a summary of the scores, then a general discussion of each individual subject, before group scores are discussed.

**Table 1: WMS-R Raw Score Subtest Results and Equivalent Percentile Score as per Age.**

| | | *Digit Span* | | | | *Logical Memory I & II* | | | | *Visual Reproduction I & II* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *FWD* | | *BWD* | | *LM I* | | *LM II* | | *VR I* | | *VR II* | |
| *Subject* | *Age* | *RAW* | *Percentile* | *RAW* | *Percentile* | *RAW* | *Percentile* | *RAW* | *Percentile* | *RAW* | *Percentile* | *RAW* | *Percentile* |
| A | 29 | 12 | 99 | 5 | 26 | 13 | 4 | 11 | 13 | 31 | 31 | 8 | 1 |
| B | 44 | 11 | 94 | 6 | 53 | 18 | 25 | 10 | 14 | 27 | 16 | 23 | 17 |
| C | 31 | 11 | 95 | 11 | 98 | 17 | 16 | 10 | 10 | 28 | 17 | 26 | 21 |
| D | 26 | 7 | 20 | 3 | 4 | 12 | 3 | 15 | 22 | 0 | 1 | 0 | 1 |
| E | 22 | 6 | 12 | 5 | 26 | 8 | 2 | 4 | 1 | 26 | 10 | 26 | 18 |
| F | 31 | 6 | 14 | 3 | 4 | 20 | 24 | 7 | 5 | 34 | 56 | 31 | 51 |
| G | 22 | 7 | 18 | 4 | 14 | 13 | 4 | 11 | 9 | 37 | 76 | 37 | 88 |
| H | 40 | 8 | 51 | 5 | 27 | 8 | 3 | 5 | 6 | 34 | 56 | 17 | 7 |
| I | 25 | 8 | 43 | 4 | 11 | 20 | 24 | 16 | 24 | 35 | 65 | 30 | 44 |
| J | 33 | 9 | 58 | 3 | 4 | 11 | 3 | 2 | 1 | 8 | 1 | 0 | 1 |

*Norms as per WMS-R manual (Wechsler, D, 1987*

Individual subject scores are depicted in percentiles, appropriate for their specific age group as obtained from the norm tables in the manual. Classification of percentiles is according to the following ability ranges: Very superior (98$^{th}$ percentile and above), superior (91$^{st}$ percentile to 97$^{th}$), high average (75$^{th}$ to 90$^{th}$), average (25$^{th}$ to 75$^{th}$), low average (9$^{th}$ to 24$^{th}$), borderline (2$^{nd}$ to 8$^{th}$) and retarded (below 2$^{nd}$).

Of note are all percentiles scores below 25, which denotes lower than average ability. On DF, which gives an indication of attentional ability, only three subjects were lower than average, while half of all subjects on DB (added complexity to attentional ability) were lower than average of which three were in the borderline range. Seven subjects' percentile scores for LM I (auditory immediate recall ability) indicated below average ability, of which six were within the borderline range. On LM II, (delayed auditory recall ability) nine subjects obtained scores in below average ability and nine fell within the borderline range. VR I (immediate visuo-spatial recall) percentile scores indicated that four subjects are within the below average range and only one of them have borderline ability. On VR II, (delayed visuo-spatial recall) seven subjects obtained below average ability range percentile scores of which four were borderline ability scores. Only one subject obtained borderline percentile scores on all the sub-tests except for DF that was within the average range.

**Table 2: Rivermead Behavioural Memory Test : Screening Score**

| Subject | | Names | Belonging | Appointment | Pictures | Story Immediate | Story Delayed | Faces | Route Immediate | Route Delayed | Message | Orientation | Date | *Totals* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *A* | *Before* | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 3 |
| | *After* | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 5 |
| *C* | *Before* | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 7 |
| | *After* | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 9 |
| *D* | *Before* | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| | *After* | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| *E* | *Before* | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 7 |
| | *After* | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 10 |
| *F* | *Before* | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 6 |
| | *After* | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 7 |

***Mean for before test = 5 and SD = 2.34; Mean for after test = 6.8 and SD=2.86***

For the screening score, one mark was awarded for a correct response to a presented item and a zero for a wrong response. Potentially a total score of 12 is obtainable for correct responses to all items. Of interest is the fact that only two subjects obtain less than 5 marks on the before test and only one subject on the after test. All subjects showed an increase of at least one mark on the after test and since this test measure everyday memory functioning ability, it appears as if there was a trend towards improvement. This might have been due to chance, since no marks improved markedly. Subject E who improved his score by three marks obtained the highest improvement in scores.

**Table 3: Benton Visual Retention Test Scores for Number Correct And Number Error.**

| Subject | NC=Number correct | NE=Number of errors | Before (Form C) | After (Form E) | Expected Score | Increase or decrease |
|---|---|---|---|---|---|---|
| *B* | *NC* | | 7 | 8 | 8 | 1 |
| | *NE* | | 3 | 6 | 2 | 3 |
| *G* | *NC* | | 7 | 8 | 8 | 1 |
| | *NE* | | 7 | 6 | 2 | -1 |
| *H* | *NC* | | 5 | 8 | 8 | 3 |
| | *NE* | | 14 | 8 | 2 | -6 |
| *I* | *NC* | | 6 | 8 | 8 | 2 |
| | *NE* | | 11 | 7 | 2 | -4 |
| *J* | *NC* | | 2 | 1 | 8 | -1 |
| | *NE* | | 15 | 19 | 2 | 4 |

Number Correct scores and Number Error scores of each subject are compared to the Expected Score based on estimated premorbid IQ score and age group. The means 'before' for NC = 5.4 and the NE = 10. Means "after" for NC = 6.6 and NE = 9.2. From Table 3, it appears as if there was a trend towards better NC performance, and a decrease in the NE scores. Subjects H & J showed a marked performance increase in NE scores. Memory for visual spatial information is elicited by this test and as such it appears from the identified trends as if memory in this domain improved.

However, the expected scores are an indication of expected performance of healthy subjects, and all subjects that were assessed on this test performed below this expectation. The manual for the Benton states that brain injured persons on average obtain 1 – 2 points less on NC scores and 5 points more on NE scores than healthy persons. Even when this is kept in mind, the performance of most the subjects was below the expected. Of note however, is the NE score of Subject J which increased by 4 points after administration of the programme.

## General Discussion Of RMBT And Benton Results

Administration of the Mega Memory® System resulted in higher scores for some subjects, indicating a positive effect on memory functioning. However, when the group results were analysed the change in performance did not reach statistical significance. ($W+=0$, $W-=15$, $n=5$, $p<0.0625$), however memory performance of the subjects on the Benton group did show a significant improvement (NC: $W+ = 2$, $W- = 13$, $n = 5$, $p <= 0.1875$) but not for (NE: $W+ = 9.50$, $W- = 5.50$, $N = 5$, $p <= 0.625$). This dichotomous result is probably due to the score value ranges and differences of the individual subjects' performances on the pre- and post-tests. This highlights the difficulties of small group studies in that one subject may perform differently from the rest, which can skew the results, e.g. in the RMBT only points with a value of 0 or 1 was awarded to items scored correctly or incorrectly, while scores on the Benton could range from 0 to 10 (NC) and even more than 20 for (NE).

Bigger values of scores provide larger latitude in mathematical computations and in statistical processes, and thus provide better input for determination of the test statistic and p values. Due to the small sample size and the confounding results of the group tests, individual scores of subjects were analysed to determine if any significant changes in memory functioning for the individual subjects could be detected.

## Discussion of Individual Subjects' Test Results

## Subject A

Subject A was 29 years of age at the time of the study. Time elapsed since the MVA accident was 6.9 years and his Glasgow Coma Scale reading was 7. This person suffered a right parietal intra-cerebral haematoma and right frontal lobe damage. Subject A has been with Headway Gauteng for four years and has undergone several different rehabilitation interventions such as physiotherapy, speech therapy and other interventions designed and conducted by the occupational therapists. On the whole his relationships with his family (who also are the primary caregivers) appears to be stable since they had enough time to adjust to the new demands placed on them as result of the TBI that the subject suffered. Subject A needs a walking frame to be able to move around and has difficulty speaking, but makes use of communication cards when necessary.

As shown in Table 1, subject A's performance on the digits forward subtest was 12 (99th percentile) was excellent. However his performance on the digits backward subtest dropped to 5 (26th percentile). This very large discrepancy between the DF and DB scores indicates excellent short-term storage capacity but relatively impaired working memory capacity. Thus his retention of information when a complex transformation of the sequence takes place is very poor and may indicate impaired attentional abilities (Jooste, 2000) Visual reproduction performance ability of Subject A ranged from average (31st percentile) for the VR-R I subtest to retarded (1st percentile) for the VR-R II.

This suggests that subject A has difficulty with the retention of visual information, especially for long periods. Subject A's ability for short-term verbal memory fell in the borderline range (4th percentile core on LM I). LM II percentile score was in the low average range (13th percentile). It would appear as if subject A thus has an impaired ability to attend to complex verbal information and retain it long enough to be consolidated into LTM. The anomalous LM II score (delayed story recall ability) on the WMS-R that is higher than his LM I score (13th vs. 4th percentiles) suggests that he may have difficulty attending to the task in hand and that his level of focussed attention fluctuated during the performance of the tasks Overall, it would appear that subject A has impaired ability to attend to any form of complex information and to retain it for any period, although he had excellent storage for simple numbers. He could however not manipulate them and when it came to more complex verbal and visual information; his immediate recall was reduced as well as his delayed recall.

On the Rivermead, subject A showed a better memory for everyday events, after administration of the programme (score increased from 3 – 5) which was significant ($t=1.48$, $df=11$, $p=0.166$). Although subject A has, an impaired ability to attend to complex verbal information it is interesting to note that he improved on the story delayed item of the Rivermead, which involves the manipulation and retention of verbal information. It thus appears as if the programme did have a positive effect on the active articulatory loop process of the verbal component of working memory, enabling subject A to improve his ability for delayed recall.

### Subject B

Subject B, at age 44 was the oldest of the subjects and one of only two of the subjects to have suffered a CVA. The nature of his injury involved chronic subdural brain swelling, and right hemisphere subdural haematoma. Subject B reported several symptoms since the accident that are concomitant with TBI: He reported bouts of *déjà vu*, differences in smells, differences in hearing, sometimes slurring of words, twitching muscles, vision blurring at times and some motor co-ordination difficulties. He admits that these symptoms are not constantly present but do occur often. Subject B uses anti-depressant medication on a daily basis.

DF ability of subject B was within the in the superior range ($99^{th}$ percentile) with DB falling in the average range ($53^{rd}$ percentile). This rather big difference indicates a problem with retention of and manipulation of numerical information. LM I scores placed subject B within the average ($25^{th}$ percentile) range for short-term recall ability on verbal information, but placed his LM II ability in the low average range. His visuo-spatial abilities all fell within the low average ranges (VR-R I = $16^{th}$ percentile and VR-R II = $17^{th}$ percentile). This denotes a compromised ability to retain both verbal and visual information in memory thus compromising the encoding function and lay down of information in LTM. On the Benton, subject B obtained a NC score of eight as opposed to the pre-test score of seven and when compared to the before test, subject B obtained a score of six for NE. His overall scores thus did not improve significantly (NC: $t=1$, $df=9$, $p=0.343$; NE: $t=1.41$, $df=9$, $p=0.193$). In this case the Mega Memory® System did not appear to significantly benefit the visual component of working memory.

## Subject C

Subject C showed the least difficulty in everyday functioning when compared to his fellow subjects, although his Glasgow Coma Scale was rated as a "7" on admission after his accident, which entail brain stem injury with cerebral contusions and a resultant six and a half week coma. At the time of the accident subject C was 27 years old and at the time of the study 31. He suffered slightly from co-ordination problems, especially on the left side, but these have improved over time. Subject C reported often feeling anxious since the accident, and is using an anti-depressant for this.

Results on the WMS-R subtests for subject C indicate a superior ability for short-term memory storage and attention span: DF fell within the superior level (between 91 and 95$^{th}$ percentile) and DB in the very superior level (98$^{th}$ and above percentile), indicating a superior immediate recall ability for figures, as well as the ability to manipulate these even when some complexity is added to the task. However, Logical Memory I and II as well as VR-R I and II all fall within the low average range (16,10,17,21 percentiles respectively). Since Subject C appear to have superior attentional and recall capacity, it is inferred that Subject C experience encoding and decoding of information problems. Thus, it can also be inferred that he would normally be free from distractibility, but that consolidation of information deficient resulting in an inability to access, store or retrieve information from long-term memory.

On the RBMT, subject C managed a higher "after" score for "Second Name" and "Belonging" items that may indicate that his ability to access previously stored information increased. Second name and belonging items relate to articulatory loop and visuo-spatial components of working memory, and as such, it is inferred that the programme had a positive effect on these aspects of memory. Subject C's scores increased from 7 to 9 which does not represent a significant increase in memory functioning (t=1.48, df=9, p=0.166).

### Subject D

Subject D suffered diffuse white matter injury, right frontal damage as well as swelling in the right temporal area because of a MVA. He reported constant feelings of anxiety, and reported tremors in his left hand. Subject D could not remember clearly, when his accident happened. His age at the time of the study was 26 and his age at the time of the accident 22.4 years. This subject had a GCS of "8" after admission to hospital.

Subject D obtained low average and borderline range scores for DF ($20^{th}$ percentile) & DB ($4^{th}$ percentile) subtests. This indicates deficiencies in attention span. Immediate recall ability is compromised and subject D will have difficulty maintaining information while manipulating it, which may compromise his ability to commit any new information to long-term memory or learn any new information. He also obtained borderline scores for VR- II and I ($1^{st}$ percentile) denoting significant problems with figural and spatial memory. Logical memory scores were within the borderline range ($3^{rd}$ percentile) for LM I and low average range for LM II ($22^{nd}$

percentile). This anomalous score for LM II seems contradictory to subject D's other test scores.

The reason for this higher score is not obvious, even when compared to his Rivermead test results which showed no significant increase form 2 to 3 ($t=1$, $df=11$, $p=0.33$). Still, this denotes a slightly better function of delayed recall for verbal information as opposed to immediate recall, which suggested that an ability to retain verbal information before committing it to memory to some extend does exist. An explanation of this anomaly may be found in that the executive controller functioning appears to be insufficient to allow the subject to focus on information in a consistent manner resulting in erratic or even a delayed performance. This is concomitant with his poor performance on the digits subtest, where attention requirements for information maintenance are deficient. Overall, Subject D's scores are indicative of severe memory impairment.

## Subject E

Subject E sustained contusions to the left frontal and temporal lobes during a MVA when he was aged 19. At the time of the study, subject E was 22 years old. Subject E suffers from instances of *déjà vu*, co-ordination problems, and claims to have recurring thoughts about the accident. This subject is on daily anti-epileptic medication.

DF ($12^{th}$ percentile) & DB ($26^{th}$ percentile) test results fell within the low average and average ranges respectively. The DF score is indicative of some immediate recall, attentional and concentration problems, although the DB score indicates an ability to maintain information while manipulating it. This would indicate an ability to consolidate information but the LM I & II scores ($2^{nd}$ and $1^{st}$ percentiles) refute this. It is rather indicative of borderline verbal abilities, which means that the audio component of working memory is dysfunctional. Similarly, VR-R I & II ability scores ($10^{th}$ and $18^{th}$ percentiles) are within the low average range, which indicates an inability to maintain and manipulate visual information.

Since DB, which involves a stronger central executive component than DF and VR-R II (dependent on relayed recall), is higher than VR-R I, it may indicate that this subject has stronger visuo-spatial abilities than verbal abilities (Gerton et al., 2004). RBMT results for “First Name”, “Second Name” and “Story Immediate” items showed no significant improvement ($t=1.91$, $df=11$, $p=0.08$) when Subject E’s test scores for pre- and post-tests is compared. These items utilise immediate recall, which is dependent on both the phonological loop for accumulation of verbal material, and the active articulatory rehearsal component that preserves and processes the verbal material. It appears as if both the audio and visuo-spatial sketchpad components of working memory are largely compromised which will make everyday functioning, relying on working memory hard for this subject.

## Subject F

Subject F was a regular attendant of the Headway Gauteng Rehabilitation Centre. He suffered a TBI with severe cranio-cerebral injury and a fractured skull with low-density changes in right frontal region. At the time of the accident subject F was 24 years old with six years having elapsed until the date of the research study. At the time of the study, he suffered form a weakened right side and complained of constant pain in his right hand.

This subject obtained scores falling within the average ability level for VR-R I & II (between 25$^{th}$ and 75$^{th}$ percentiles) but obtained a score falling within the borderline ability level for LM II and DB (between 2$^{nd}$ and 9$^{th}$ percentiles). LM I (24$^{th}$ percentile) is within the average ability range. It appears as if subject F's ability to hold information e.g. number and verbal and to manipulate the information is compromised. Thus, it can be inferred that the functional ability of the executive controller is compromised when large quantities of information is received. The overall lower scores that Subject F obtained for the LM subtests, as compared to the VR-R subtest, are indicative of deficiencies of the audio component of working memory. The VR-R I and II scores were indicative of an overall more efficient visuo-spatial loop functioning. However, since both LM I and VR-R I subtest scores were higher than the LM II and VR-R II subtest scores, it appears as if consolidation of information, may be less efficient. The RBMT test results of subject F showed an increase in score for "First

Name” item only. All other items scored similarly. This increase of one point represent no significant increase (t=1, df=11, p=0.33).

**Subject G**

Subject G (aged 22) suffered a TBI at age 19 as result of a MVA. This subject reported memory problems for ‘common’ things e.g. finding the word for a car. He claimed that he could recognise it for what it was, but could not name it. He also suffered from motor-coordination problems, but did not need any aid for perambulation. Sleep patterns seemed to be disturbed, but the subject did not take any medication. Family support was excellent and the subject was a regular attendee at the Headway Gauteng Rehabilitation Centre.

Subject G obtained scores falling within the low-average range for both DF (18$^{th}$ percentile) & DB (14$^{th}$ percentile) subtests indicative of some attention span and concentration problems. The DB score may be indicative that the central executive experience information overload when presented information is more complex. VR-R II & I scores (76$^{th}$ and 88$^{th}$ percentiles) fell within the high average ability range, indicating a high memory functioning ability for visually presented information e.g. designs and figures. However, LM I & II scores fell within the borderline (2$^{nd}$ to 9$^{th}$ percentile) range, indicating impaired ability for verbally presented information and thus everyday memory tasks. Since the LM subtest loads heavily on the articulatory loop component of working memory, these scores are indicative of phonological loop and rehearsal process deficiencies.

Benton test results which loads on the visuo-spatial component of working memory, did not show a significant increase in scores (NC & NE: t=1, df=9, p=0.34), Subject G improved on the number correct score, increasing from an initial score of seven correct to eight correct.

## Subject H

Subject H suffered a CVA at age 34, six years prior to this study. This subject also reported no side effects post TBI other than a general co-ordination problem, affecting the whole right side of his body. His wife however, who emphasised the fact that he is very forgetful, does not supported this notion. His spouse is very committed to assisting him with rehabilitation and thus his has a good support system.

Subject H obtained average ability scores on the DF ($51^{st}$ percentile) & DB ($27^{th}$ percentile) subtests indicating an average ability for attention span and immediate recall short-term memory ability. LM I & II subtest scores fell within the borderline ability range ($3^{rd}$ and $6^{th}$ percentiles) and VR-R I & II within the average ($56^{th}$ percentile) and borderline ($7^{th}$ percentile) ability ranges respectively. Although immediate recall ability for number items is average, the lower DB ability is indicative of compromised retention ability. LM scores denoted compromised ability of verbal material for both immediate recall and delayed recall. This is corroborating the statement from his wife about his forgetfulness. It is also an indication that the articulatory loop component of working memory is ineffective. VR-R I & II scores (56th and $7^{th}$ percentiles) showed an relatively intact immediate recall visual memory ability, although delayed recall was severely compromised. Since all the delayed recall scores were markedly lower, it could be inferred that the executive controller function, which must regulate and assist with consolidation of information is compromised when large quantities of data or complexity of information is received.

On the Benton NC score Subject H obtained an eight for the 'after' test as compared to five for the before test. Subject H also made three less errors; two less placement errors and one less omission error, which suggests that the programme impacted positively on delayed recall ability of the subject for visually presented material. Overall Subject H's *t*-test results scores for NC ($t=-1.96$, $df=9$, $p=0.08$) and for NE ($t=1.5$, $df=9$, $p=0.16$) showed no significant change between the 'before' and 'after' assessments.

### Subject I

As result of an MVA Subject, Subject I sustained a major diffuse head injury with skull fracture causing brain damage at age 21. His GCS on admission to hospital was rated as eight and the subject was comatose for approximately three months. He reported spells of dizziness, vision problems, forgetfulness, twitching of muscles, *déjà vu*, and some coordination problems. He takes pain medication on a daily basis as well as an anticonvulsant / mood-stabiliser.

Subject I obtained an average score ($43^{rd}$ percentile) for DF subtest and low average ability ($11^{th}$ percentile) for DB. The DF score is indicative of a relatively intact immediate recall ability, but it appeared as if the concentration and attentional component is compromised especially when an increase in complexity during task execution is experienced.

LM I & II scores were similar ($24^{th}$ percentile) and just below average ability levels thus denoting some difficulty with verbal information retention and recall. VR-R I & II subtests scored within the average ability range. The higher VR-R I score ($65^{th}$ percentile) may be indicative of average immediate recall ability for visual information, whilst the lower average score of the VR-R II subtest, ($44^{th}$ percentile) denotes a slightly impaired ability for delayed recall in the same domain.

Subject I obtained three points more on the Benton for the ‘after’ test as compared to the ‘before’ tests on NC score, but also showed an increase of one in the NE score. The increase in NC score may be indicative of more efficient utilisation of visuo-spatial memory after administration of the Mega Memory® System. The difference in scores indicated a significant increase in memory functioning. NC ($t=-1.5$, $df=9$, $p=0.167$) and for NE ($t=0.71$, $df=9$, $p=0.494$).

**Subject J**

Subject J was 33 at the time of the research study. Time since his accident for this subject was 4.7 years with a GCS of “8” on admission to hospital. He sustained severe cerebral injuries, cerebral contusions and intra-cranial complications, as well as a right temporal fracture with a right parietal–temporal haematoma. The subject was comatose for three months after the TBI, and has lost sight in his left eye. Subject J was reported to exhibit some tendency for angry behaviour and was dependent on his parents for transport.

All WMS-R subscales scores obtained by this subject fell within the borderline ability range (DB, 3$^{rd}$ percentile; LM I, 3$^{rd}$ percentile; LM II, 2$^{nd}$ percentile; VR-R I, 1$^{st}$ percentile; and VR-R II, 1$^{st}$ percentile) with the exception of DF which fell within the average ability range (58$^{th}$ percentile). These scores suggested severe memory impairment. The average DF score may be indicative of an intact immediate recall memory functioning for numbers, but all other scores suggested a severely impaired verbal and visuo-spatial memory functioning ability. The severely impaired DB score is indicative of serious impairment of complex information processing. Delayed recall and learning (which involves encoding, storage and retrieval of information) all forms part of the consolidation of information, which appear to be severely impaired as indicated by the LM II & VR-R II scores.

On the Benton, subject J showed decreases in NC score and an increase in NE score. Both scores indicated that Subject J obtained no significantly different scores after administration of the Mega Memory® System NC ($t=1.0$, $df=9$, $p=0.343$) and for NE ($t=-1.81$, $df=9$, $p=0.103$). During the 'before' test, Subject J made several errors of distortion, omission and size, and during the 'after' test he tended to make similar errors, albeit one more error of size. Subject J was irritable during the assessments (more so during the 'after' assessment) and several attempts were needed to restore his attention and focus on the task before him. The higher NE score and lower NC score suggest a major overload of information on the executive controller, too complex in nature to properly enable transfer of information via the visuo-spatial loop to short-term memory, thus effectively negating any long-term memory storage. Since Subject J was able to obtain better scores during the 'before' assessment, it was assumed that his emotional state during the 'after' assessment contributed towards increasing vulnerability for attention and concentration deficits, and thus contributing towards a diminished STM process.

## GENERAL DISCUSSION

Ten TBI male subjects who attended the Headway rehabilitation centre volunteered to participate in the research study that aimed to determine if a commercially available Mega Memory® System would enhance memory functioning of TBI sufferers. If it was found to be effective, then the system could be included in a cost effective programme for the rehabilitation of TBI patients.

Following their selection the subjects were assessed on subscales of the WMS-R in order to determine their levels of general memory functioning. Subjects were then randomly assigned to a Rivermead and Benton group (five each), and were then assessed on these instruments to obtain a 'before' score, prior to administration of the Mega Memory® System. After administration subjects were assessed on the same instruments (albeit different versions) to obtain an 'after' score.

The performance of the ten subjects on the WMS-R and on the Rivermead and Benton tests before and after the intervention is reported as summary tables and case reports for each subject were prepared. The data was analysed by the non-parametric Wilcoxon test to determine whether there were significant differences between the performance of the two groups of subjects before and after their participation in the Mega Memory intervention. Overall Wilcoxon test results showed no significant improvement in memory functioning for the Rivermead group (W+=0, W-

=15, n=5, p=0.06), an also no significant increase for the Benton group (NC: W+ = 2, W- = 13, N = 5, p = 0.19; NE: W+ = 9.50, W- = 5.50, N = 5, p= 0.6).

The *t*-test results of only one individual subjects' item responses did reflected a significant change in scores between "before" and "after" tests. In some cases, better scores were obtained and it was therefore inferred that administration of the Mega Memory® System did assist with certain memory processes in some individual cases. It appears as if the programme impacted on both articulatory loop (subjects A, D, and F) and visuo-spatial loop components (Subjects A, H and I) of working memory, as well as in some instances, on the regulatory function of the executive controller.

However, subject J's memory functioning seemed worse after administration of the programme. Subject J's spirit of participation was markedly troublesome on the day of the after test, and this could possibly have contributed towards the obtained test results.

Although the Mega Memory® System appears to be uncomplicated in administration and use, it may on some level, negatively impact on the learning of the subject especially if the complexity of materials presented cannot be handled. The complexity of the material presented relates to simultaneously 'picturing' an image and then connecting this image with another object, to form an association and then to progressively build on these images throughout the programme. Some of the subjects (e.g. Subject A) who could not deal with complex materials would be disadvantaged by this characteristic of the programme. Although the techniques employed in the programme have been effective, the material was not suitable for every subject. Some subjects showed an increase in articulatory loop processes, and other in the visuo-spatial component functioning, but these changes were not significant. Subjects who obtain above average scores on the DF, DB, VR-R I & II and the LM I & II, will probably benefit more from the programme, since above average scores on these sub-tests would indicate a better ability to handle, and maintain complex information.

For rehabilitation purposes, the mnemonics as presented in the programme could possibly be simplified by limiting the tapes presented to certain subjects. For instance if a subject is unable to master complex material, exposure to the programme could be limited to the first tape, which simply use associations and teach a sequential memorisation of up to twenty items. Furthermore, should the number of items present a challenge to subjects, it could be limited to five or four and then steadily increased up to a level where the complexity becomes to large for the subject to handle.

Similarly levels of mastering complexity could be established beforehand (e.g. by using the WMS-R DB and DF subscales) or any more relevant instrument, for all participants. Programme cut-off points could then be established for each subject and material to be presented structured around these levels.

## CONCLUSION

By introducing strategies such as the ability to make use of creative visualisation, (as employed by the Mega Memory® System), it was hoped that the ability to acquire and recall new information, when needed, will improve and thus enhance memory functioning in TBI patients. On an individual case basis, significant levels of memory improvement were established. However, this was not reflected in the Rivermead group test score.

The complex nature of TBIs and the unique set of individual consequences following such an injury again became apparent through this research: Each individual that participated in the programme experienced its effects in different ways and in different areas of memory functioning.

From a qualitative perspective, administration of the Mega Memory® System can and did affect the TBI subjects positively. Without exception, all subjects responded positively when asked about the programme and their experience while participating. It does then play a role in improving the perceived quality of life of the TBI sufferer and that, on its own, should be sufficient grounds for using it.

This research did not look at the long-term effects of the Mega Memory® System on memory functioning nor did it purport to evaluate its usefulness in this regard. However, the individual case studies of these subjects suggested some improvements in the areas of short-term memory storage and retrieval, delayed recall, and functioning of the executive controller.

The intention of this research study was to determine if the Mega Memory® System could bring about an improvement in general memory functioning of TBI suffers. This was found to be the case, and as such, its usefulness as a possible aid in memory rehabilitation was established. Future research on the effectiveness of the Mega Memory® System as a rehabilitation tool could possibly benefit from employing different assessment instruments that set out to measure particular memory problems or domains. This will afford the opportunity to concentrate on specific identified deficiencies, and then to monitor change in those areas, after administration of the programme.

The effect of the Mega Memory® System on TBI patients will possibly be greater if its administration is repeated several times. A longitudinal study based on repeated administration will be a good approach to measure this.

It became apparent from this study that selection of candidates might be improved if the results from an assessment instrument (such as the WMS-R or equivalent) are employed to assist with the division of subjects into particular groups, based on identified memory deficits. This will enable researchers to target specific memory deficiencies and the effect of the Mega Memory® System on those deficiencies.

No prior research of the effect of the Mega Memory® System on TBI patients was found in literature and to this extent, this study was a first of its kind. This posed some problems in research design, but the advantages of this study lies in the creation of a yet, untapped, research field for prospective researchers into the usefulness of the Mega Memory® System in rehabilitation. The Mega Memory® System will probably never form a pivotal rehabilitation intervention, but has shown qualitative effectiveness and perhaps in future may form part of the repertoire of interventions employed to assist TBI sufferers.

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# APPENDICES

## *APPENDIX A: CONSENT FORMS*

### Informed consent form (Participant)

I ________________________________________

(Full names and surname)

Hereby agree to participate in the Mega Memory ® System study and hereby agree to the following:

1. I herewith give my permission and consent to Mr Strauss to gather information pertaining to my person, treatment, injury, and rehabilitation if no infringement of my rights takes place. I also understand that my name, address and any other personal information that may identify me will not be divulged or represented in any way.

2. I acknowledge that the results of this research project will be published as a Master Thesis.

3. I understand that my participation is voluntary and that I may withdraw at any time without any prejudice.

______________________ _________

Signature of Subject DATE

**Informed consent form (Care giver)**

I, the undersigned

______________________________________________

(Full names and surname)

Guardian/care-giver of

______________________________________________

(Full names and surname of subject)

Hereby give consent for the above-mentioned subject to participate in the Mega Memory® System.

I hereby agree and consent to the following:

1. Permission to gather information pertaining to the person, treatment, injury and rehabilitation of the subject that will not in any way infringe on any of his/her rights.

2. I also understand that all information that may identify subjects will not be divulged or represented in any way.

3. I acknowledge that the results of this research project will be published as a Master Thesis.

4. I understand that participation is voluntary and that subjects may withdraw at any time without any prejudice.

_______________________ _______

Signature Caregiver / Guardian DATE

# *APPENDIX B: INFORMATION SHEET*

## *Proposed Research Study*

Dear Subject / Family Member or Caregiver,

Patients who suffer a Traumatic Brain Injury (TBI) frequently show difficulties in coping with changes in their environment and with general functioning. One of the major problems experienced lies in the domain of memory functioning. Different rehabilitation techniques aim to improve this condition.

In this proposed study, the aim is to introduce a memory enhancement program (Mega Memory® System) and to evaluate its usefulness in rehabilitation with TBI patients. It is hoped that Mega Memory, which has as its basis, associations and by implication creative memory processes, may prove to be such a tool. It makes use of associations and very vivid mental pictures (creative thought processes) to enhance learning and recall.

In order to conduct this study, subjects willing to participate are needed. However, subjects must comply with certain criteria, and all prospective subjects will be subjected to a selection process to determine suitability for participation in the study.

Assessments (prior to and after) the administration of the programme will be conducted to firstly establish a baseline measure for memory of each individual subject, and secondly to determine extend of change brought about by the programme. The study will be conducted over a period of approximately four months. All information will be kept confidential in accordance with ethical and professional conduct guidelines and will be obtained by means of interviews, observations, records, and assessments. All data gathered will be statistically manipulated to determine if any significant change was brought about by the program.

Time slots for administration of the program have been negotiated with Headway, and all effort will be made to accommodate individual subjects. If you are interested to participate in this study, please complete the consent forms and leave it with Headway.

Thank you

Mias Strauss - Researcher.

## *APPENDIX C: GUIDANCE TO THE SUBJECT*

**<u>THE TBI & MEGA MEMORY® SYSTEM RESEARCH STUDY</u>**

January 2002

Dear [insert subject's name]

Attached you will find all the information that you may need regarding the Mega Memory® System. Please study and complete the attached forms and hand them back on your next visit to Headway.

*<u>Questionnaires</u>*

If you cannot complete some of the questionnaires or do not know some of the information, somebody who is close to you and who knows this information may complete the forms.

*<u>The Sessions</u>*

I would like to stress that it is very important that should you decide to participate in this study, you MUST attend all the sessions, or complete the assignments as set out.

You will be supplied with the necessary equipment to complete the assignments / sessions. With the exception of the memory functioning tests, the sessions will at most, take about 30 minutes to complete. Some session may even be a lot shorter.

*<u>Selection</u>*

All candidates who participate will be randomly selected by a computer to fall in either one of two groups for testing purposes. These groups will be the Benton Group and the Rivermead Group. Each subject will then be further instructed regarding the particular exercises of that particular group.

*<u>Memory functioning</u>*

Your current memory functioning will be determined using a Wechsler Memory Scale – Revised assessment. This test will give us an indication of your current memory capabilities, before we do the study. Just before we start with the sessions, you will be tested on either the Benton Visual Retention Test (Benton group) or the Rivermead Behavioural Memory Test (Rivermead group). We will again do this test at the end of the program. The interpretation of these test results will allow us to determine whether the study and program that we use were effective or not. The completion of these tests normally takes about 45 to 60 minutes.

*The Timetable and other Info*

Once the initial selection process has been completed, and subjects allocated to the two groups, the timetable regarding the program and the group specific information will be shared with you.

Thank you,

Mias Strauss (Researcher) Contact no: 12345